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# The Canadian Fish Culturist

A Department of Fisheries Publication

*A Bulletin of Information and Opinion as to Fish Culture in Canada*

VOLUME IV

No 5

MAY
1949

# CONTENTS

VOLUME IV No. 5

MAY, 1949

Page

Estimating Lake Populations—W. A. Kennedy..... 3

The Removal of Undesirable Fish from the Headwaters of Dorion Rearing Station in 1948—G. C. Armstrong..... 7

Identification of Atlantic Salmon and Brown Trout Based on a Comparative Morphological Study—Hugh R. McCrimmon..... 11

Small-Mouthed Black Bass in the Waters of New Brunswick and Nova Scotia—James Catt..... 15

The Status of the Hatchery—Richard B. Miller..... 19

Trout Fisheries in New Zealand—Their Development and Management—Book Review by A. L. Pritchard 25

Requests for earlier issues of the Canadian Fish Culturist continue to be received. A limited number of copies of the issue for August 1948, Vol. III, No. 4, remain on hand and distributions will be made on request until the supply runs out. However, no copies of the issues for November 1946 and June and December, 1947, are now available.

Published under Authority
of
Hon. R. W. Mayhew, M.P.,
Minister of Fisheries

# The Canadian Fish Culturist

*A Department of Fisheries Publication*

*A Bulletin of Information and Opinion as to Fish Culture in Canada*

VOLUME IV

No. 5

MAY
1949

# Estimating Lake Populations[1]

*by*

**W. A. Kennedy**

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Biologists have been estimating lake populations of the smaller, slower, aquatic organisms for many years. For bottom fauna a sufficient number of random samples of a known area of bottom are secured, and the number of each species is determined. The average number per unit area occurring in each type of habitat is calculated, and then, knowing now much of the lake bottom is represented by each type of habitat, the total population within the lake is estimated. Populations of plankton are similarly calculated, sampling known volumes of water rather than known areas of bottom.

These methods depend on the fact that the apparatus used is large, relative to the organisms studied, and the organisms are relatively slow. For fish and other comparatively large aquatic animals no suitable apparatus exists which would permit these methods of estimation to be used. Presumably a gigantic purse-seine fished according to some random, stratified sampling scheme would be appropriate.

There are a number of cases on record of lakes in which all the fish were deliberately killed and all that could be recovered were counted. Rounsefell (1946) has brought together information on 51 lakes of known area in which the total population has been so determined. He shows that the weight of fish per unit area is inversely proportional to water surface area, and that the following mathematical relationship exists:

log. total weight of fish in pounds per acre =
2·4294 − 0·4001 (log. acres of water surface)

That is, the average total population is about 270 pounds per acre in a one-acre pond and only about 30 pounds per acre in a 200-acre lake. Application of the above equation may be of some value in estimating lake populations. It should be realized, however, that the equation is based on results in lakes of less than 200 acres, mostly in Illinois, Michigan, Indiana and Wisconsin, and that many lakes in Canada would not support fish populations of this magnitude. Also most of the lakes were poisoned because of atypical conditions existing at the time, and further, not all of the fish poisoned were recovered to be counted.

If a lake were fished intensively so that catch per unit of effort became negligible within a season, and if repeated sampling, continued for several years, showed no appreciable change in catch per unit of effort, then the total catch in the first year would be a good estimate of the original population of catchable size in the lake. The original populations of several lakes have been estimated on the basis of fishing which approximately fulfilled these conditions.

[1] *A review presented before Committee on Biological Investigations, Fisheries Research Board of Canada, Ottawa, January 4, 1949.*

## Direct Count Possible Without Killing

Sometimes special circumstances make possible a direct count without killing the fish. For instance bodies of water may be suddenly drained, as about 1,000 acres of the Winnipeg River, Manitoba, recently were in connection with a power development, or certain species may migrate annually out of a certain area by way of a narrow exit where it is possible to capture and count them, as in Whitetrout lake, Algonquin Park, Ontario.

Biologists would welcome some means of using availability, which is catch per unit of effort, to estimate populations. However, there is no method now in use by which this can be done. Because of the many unknown factors involved it is probably not even safe to place too much trust in estimates of relative populations on the basis of relative availabilities. In a few cases availabilities have been calculated for lakes where good estimates or counts of population are also recorded. No doubt when sufficient data of this sort have been accumulated they will be useful in estimating populations.

Bajkov (1932) has used Derzhaven's method for estimating the whitefish *(Coregonus clupeaformis)* populations of Lakes Winnipeg, Winnipegosis, and Manitoba. Total annual catches for 1916–1928 from the lakes in terms of numbers of fish, plus a random sample from the catch in each for age determination, were required for such calculations. As an example, 3·4 per cent of the fish in a random sample from Lake Winnipeg in 1928 were in their 13th or subsequent year of life, so that of the 1,000,000 whitefish caught that year approximately 34,000 were survivors of the 1916 year class (lumping the negligible few from the 1915, 1914, etc., year classes with the 1916 year class). Similarly, of 942,000 caught in 1927 approximately 50,870 were survivors of 1916 and 1917 year classes. Summation of all such values calculated for the years 1916–1928, inclusive, gives all the 1916 year class fish caught in 14 years, all the 1917 year class fish caught in 13 years, etc., that is, the total population present in 1916, if natural mortality is presumed to be negligible.

As Ricker (1948) points out, these particular calculations are of little value. The method assumes a uniform rate of exploitation over the time considered (which has not been the case), a uniform rate of recruitment (which has probably not been the case), and negligible natural mortality (which is unlikely, especially in the first year of life). Natural mortality can be a very important factor. In unexploited lakes all mortality is natural mortality, and some approximate values for annual mortality rates which have been calculated for whitefish in such lakes are as follows: Lake Opeongo, Ontario, 50 per cent; Shakespeare Island lake, Ontario, 10 per cent; Kakisa lake, Northwest Territories, 50 per cent; Great Bear lake, Northwest Territories, 30 per cent.

Fry (in press) has followed the Lake Opeongo lake trout fishery for longer than a year class is vulnerable to the fishery, and so is in a position to make similar calculations which are unaffected by any fluctuations that may have

taken place in fishing intensity or in recruitment, although he has not actually made such calculations. He has an estimate of natural mortality, which is apparently of less importance than fishing mortality.

## Best Method for Estimating Fish Populations

Apparently the best method for estimating fish populations is to catch some of the fish, mark them in some way, release them alive, allow them to mix thoroughly with the unmarked fish, then draw a large random sample from the population, and from the ratio of marked to unmarked fish in the sample, and knowing the total number marked, calculate the total population. Generally the "large random sample" is actually drawn by a fishery, with provision made for observers to record proportion of marked to unmarked fish.

The necessary calculations are straightforward if all the fish are tagged immediately before fishing begins, and if observations on the ratio of tagged to untagged are carried on for only a short time. There are a few factors that have to be considered, however, and due allowance must be made for their effects. Tags and other marks are notorious for causing abnormal mortality. The presence of a tag may change the odds of a fish being captured, as for instance, the tag may entangle in a gill net which would otherwise fail to catch the fish, or a jaw tag may lead to a decreased tendency to take a baited hook. Tags may be lost, and mutilated parts may regenerate. Fish of different sizes may not be equally vulnerable to the fishery. The marked fish may not be thoroughly mixed with the unmarked ones.

In this connection it is important to realize that part of the population may be "uncatchable". For instance, Carlander and Lewis (1948) estimated that there were 300 black bullheads *(Ameiurus melas)* in a certain pond on the basis of capture by seining, tagging, and recapture by seining. After poisoning 1,350 were counted. He felt that very close to the estimated 300 bullheads were swimming around at the time that the estimate was made and that the remainder were lying in the bottom mud where they escaped the seine both times, that is, they were "uncatchable". Carlander and Lewis actually made an estimate of "catchable" fish.

If marked fish are recovered over a longer time, the necessary calculations are more complex, and factors in addition to those listed above must be considered. Fish too small to be taken at first will grow and enter the fishery. Marked fish may disappear because of natural mortality. If marked fish are caught but not recorded, the estimates will be distorted.

There are also methods of estimating populations where tagging takes place during the fishing season, and when recoveries are made for more than one year. Ricker *(loc. cit.)* outlines methods which apply to all situations likely to be encountered.

The above remarks may be summarized as follows:

1. A number of fish populations have actually been counted and these counts may be useful in estimating other populations.

2. At present, catch per unit effort is of little use in estimating fish populations.

3. The sums of the number of fish in each year class in the annual catch may be used to estimate a former population, if allowance is made for natural mortality.

4. Marking and releasing fish for subsequent recapture is the best method now available for estimating fish populations.

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# The Removal of Undesirable Fish from the Head Waters of Dorion Rearing Station in 1948

*by*

**G. C. Armstrong**

*(Biologist, Ontario Department of Lands and Forests)*

The renovation of the Dorion rearing station afforded an ideal opportunity to rid the headwaters of the hatchery of infected fish. Previously, when the hatchery was in operation, a number of the diseases encountered were directly attributed to the permeation of the infectious diseases from the fish in the pond. This condition was almost impossible to remedy without transferring the complete stock of fish and closing the station for a period. Nets were set in the pond but while this procedure undoubtedly controlled the population it did not reduce it sufficiently to destroy this source of infection.

When the construction operations had progressed sufficiently to permit the permanent damming of the headwaters, plans were drawn up for the removal of the fish population by a treatment of Calcium Hypochlorite (HTH). Before this treatment was carried out it was thought necessary to reduce the abundant growths of submerged aquatic plants. While the plant life in itself was not of direct concern, it would undoubtedly reduce the strength of the chlorine and retard the penetration of the chemical.

The headwaters or pond covers an area of approximately six acres. With three stop-logs in the dam the volume of water was estimated at 105,600 cu. ft. or 660,000 gallons. The average depth of the pond would be about four feet. The bottom is principally mud and clay with a small area of gravel along the east shore.

The pond is fed by a number of springs scattered about the eastern portion. Considerable seepage also enters the pond from the east and north-eastern banks of the shoreline. The rate of flow produced by these sources was estimated at 7,516 gallons per minute.

## Matted Beds Three Feet Thick Not Uncommon

The plants cover almost the entire bottom with the exception of areas about the larger springs and gravel beds which were almost void of plant life. However, in other portions, matted beds three feet thick and covering an area of a square yard or more, were not uncommon. These latter areas were heavily laden with silt and quite resistant to the eddies stirred by the springs.

The reduction of the plant life appeared necessary to ensure complete destruction of the fish population. In reducing the aquatic plant population both chemical and mechanical methods were used. Raking was conducted by one man for a period of ten days. Each day an average of ten punt-loads were removed from the pond but at the end of the period, these one hundred or so punt loads had made very little impression on the total growth.

Following this operation the pond was chemically treated with four hundred pounds of copper sulphate. The treatment was carried out by dispersing the powder over the surface of the water. The pond was divided in four areas and four boats, each manned by two men, spread one hundred pounds of the chemical over their respective areas. Unfortunately the powder which had been stored at the station was in a dampened condition and large lumps had to be crushed before the dispersal.

When the application had begun, the stop-logs were added to the dam. The water was backed up for a period of two hours in which time the solution became much diluted. The stop-logs were then removed, two at a time, until the water had assumed its original level.

### Thought Inflow Distorted Concentration

In evaluating the results of the treatment, no apparent reduction or kill of the aquatics was noted. During the treatment three fish appeared to be in discomfort but no actual deaths were observed, although, theoretically the strength of the solution was approximately 60 p.p.m. Immediately following the application it is thought the tremendous inflow of water distorted this concentration. Other factors, such as the moistened condition of the chemical and the period of time required for distribution, combined to reduce the toxic effect of the treatment.

In view of these results, numerous mechanical methods were devised and tried. First, a wire seine was put in operation. The seine was carried out to the centre of the pond by two boats. Then with a man operating each end from a punt the seine was hauled ashore by two horses. This method proved ineffective because the gradient of the bank was too steep and it was impossible to keep the poles and seine from digging into the bank and upturning. This method was abandoned in favour of fitting a wire netting cage to the rear of a set of harrows. Two guide wires fastened to the cage and leading edge of the harrows supported the basket-shaped net. This apparatus was carried by punt to the centre of the pond and dropped overboard. A team of horses then hauled it ashore. This method, although crude, did clean a considerable portion of the bottom. However, only half the pond could be worked as the horses could only operate along the south shoreline. The steep banks and heavily wooded shoreline to the north impeded further operations with the use of this mechanism.

The final and most efficient method involved the use of a heavy iron cage operated by a winch. The cage was hauled by a cable which stretched from the winch across the pond through a pulley attached to a tree and finally fastened to the cage. A return cable from the opposite end of the cage to the reverse drum of the winch brought the cage back. With this set-up the cage collected a swath of weeds in each trip across the pond.

The cage was built eight feet long, three feet high and four feet wide. The bottom and removable back door were made of 3/8″ steel plate. The sides were of heavy wire screening of 1″ mesh supported by an angle iron frame.

The top of the cage was open. At each outside corner end an extra piece of angle iron was welded on forming a groove which secured the removable gate.

Following a few experimental trials the cage was cut to half the length and extra angle iron supports were added to the tail gate and sides. Originally when the cage was loaded, it placed too much strain on the cable and winch and it is doubtful if the cage itself could have withstood many heavy loads.

The modified cage when placed in operation worked very effectively. As the program progressed a change was made in the pulley hook-up. Rather than transfer the pulley from tree to tree, a short length of cable was strung between two trees running parallel to the shore and as the areas were cleaned the pulley was moved along the cable.

This operation was conducted for three days and together with the results previously attained, the growth was considerably reduced. Odd, small patches still remained but they were not large or dense enough to reduce the HTH treatment appreciably.

### Treatment with HTH

All the springs or depressions in the bottom were marked by long poles to ensure that sources of fresh water would be heavily treated. For this reason burlap sacks were filled with varying amounts (10–25 lbs.) of the chemical. These sacks, 25 in number, were then distributed to 20 odd depressions. In some instances where the springs were very active, a partly filled barrel or two bags were sunk to the bottom of the spring. The sacks were all weighted and tied to the stake in order that a concentrated solution would be present at the inlet. Following the distribution of the sacks the four boats used in this operation were loaded each with a barrel of the chemical. One boat manned by two men mixed the solution and sprayed it over the surface waters while the other three boats also manned by two men spread the solid particles over the surface. The seepage waters entering the pond from the east shore were treated thoroughly by one man detailed for the task. The four boats employed covered the area of the pond four or five times until a total of 1,500 pounds of the chemical had been dispersed. Numerous tests for the strength of the solution with orthotolidine indicated a very strong solution. At the beginning of the operation all the stop-logs were pulled in the dam and the pond was lowered to the limit. One man was posted at the dam to replace the logs on the first indication that the solution was coming through. At this moment the 13 logs were added. The time required for the water level to reach the top of the stop-logs was about three hours.

The effects of the treatment was noticeable shortly after the first application of the chemical. The speckled trout *(Salvelinus fontinalis)* exhibited very little resistance to the treatment. Hectic signs of distress were noted shortly after the trout were subjected to the chemical. The majority of the trout had succumbed 15–30 minutes after the initial application. The spoonheaded muddler *(Cottus ricei)* was also present in very great numbers.

These fish appeared much more resistant to the treatment. While they displayed signs of distress they appeared able to endure the toxic environment much longer than the trout. A few muddlers survived for three hours or more, however, a later examination revealed no fish life whatsoever. A number of earthworms were noted on the bottom. These too appeared overcome by the chemical.

When the solution reached the top of the dam and began overflowing, the neutralizer was applied. This operation was conducted by suspending two sacks full of sodium thiosulphate just above the overflow. Four hundred yards downstream by the remains of an old damsite a further application was added. Here, three bags of neutralizer were suspended in the narrow channel. Between the two dams the chemical still persisted until the headwaters cleared. Below the second dam, after the water had flowed through the neutralizer for the second time, the waters were tested and results indicated a very weak solution of the chemical.

The effects of the chemical between the two dams may have proven toxic to a few of the animals present. A number of muskrats housed along the border of this discarded pond were very much aroused when the solution reached the area. Although in a diluted state the chemical was still quite evident and these muskrats quickly left the water. A number of fish were seen floating down through the second dam but it was thought that the majority of the fish were flushed over the first dam.

During the evening as the bags of neutralizer were dissolved more chemical was added. By 10.00 p.m. the solution was in a much diluted state. The bags were filled once more and the operation was abandoned. A total of 800 lbs. of sodium thiosulphate was used during the operation. By morning a survey of the pond and stream revealed no trace of the chemical. Numerous dead muddlers and speckled trout were observed on the bottom of the pond. The cleaning up operations of removing the fish carcasses, poles, empty drums and bags completed the operation.

# Identification of Atlantic Salmon and Brown Trout Based on a Comparative Morphological Study

*by*

**Hugh R. McCrimmon**

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Atlantic salmon *(Salmo salar)* and brown trout *(Salmo trutta)* are often not readily distinguishable. The study here reported was undertaken for the purpose of finding some diagnostic features which might be depended on to separate them. Part of the material examined was obtained from the collection of the Royal Ontario Museum of Zoology through the courtesy of Prof. J. R. Dymond. The remainder was collected from Duffin Creek, Ontario County, Ontario. The number examined was 41 Atlantic salmon and 41 brown trout. In all 35 Atlantic salmon and 35 brown trout with lengths from 55 to 230 millimeters were examined, and also six salmon and six trout with lengths from 300 to 780 millimeters.

## Methods

The material from Duffin Creek was collected from 1945 to 1948. All the material was examined during 1947 and 1948.

Measurements of the various body characters commonly used by systematic ichthyologists were employed in this study. Measurements made were standard length, body width and depth, head length and depth, caudal peduncle length and depth, eye, snout, interorbital, and maxillary length, number of rays, height, and length of dorsal and anal fins, length of pectoral and pelvic fins, number of branchiostegals and gill-rakers, number of scales on lateral line and from posterior of base of adipose diagonally to lateral line.

## Results

A. A Comparison of Meristic Structures.

(1) Scale counts.

*(a)* Lateral line scales. This is a measurement of oblique scale rows from the posterior margin of the head to the end of the vertebral column. Difficulties arise in the determination due to the branching or insertion of extra scale rows particularly along the anterior portion of the body. An exact count is particularly difficult in the smaller specimens.

For *S. salar* the number of scale rows was found to have mean value of $111 \cdot 2 \pm 1 \cdot 2$. The number of scales along the lateral line of *S. trutta* gave a mean value of $112 \cdot 3 \pm \cdot 82$.

*(b)* Scales form the posterior base of the adipose to the lateral line. Counts were made along the diagonal scale row and the scale touching the lateral line was excluded from the count. Determinations on the diagonal scale row gave a mean value of 10·8 ± ·82 for *S. salar* and of 15·2 ± ·16 for *S. trutta*.

(2) Dorsal fin rays.

Both species were found generally to have 12 developed dorsal rays. The majority of the fish possessed one or two rudimentary rays followed by one or two undivided rays, followed by 10 or 11 divided rays.

(3) Anal fin rays.

Anal fin rays vary in number from 9 to 11 for both species. The most common arrangement was one rudimentary, one divided, and 8 undivided rays.

(4) Gill-rakers.

The number of gill-rakers on the first arch on the left side gave a mean value of 19·8 ± 1·6 for *S. salar*. A mean value of 17·0 ± ·01 was obtained for *S. trutta*.

(5) Branchiostegals.

The number of branchiostegals on the left side was found to give a mean value of 11·9 ± ·03 for *S. salar* and of 10·0 ± ·01 for *S. trutta*.

(6) The counts which have been found to show a difference for the two species are presented in the following table.

**Table I**

| Character | *Salmo salar* | *Salmo trutta* |
|---|---|---|
| Number of scales from posterior of base of adipose to lateral line | 10·8 ± ·82 | 1 ·2 ± ·16 |
| Number of branchiostegals on left side | 11·9 ± ·03 | 10·0 ± ·01 |
| Gill-rakers on first arch of left side | 19·8 ± 1·6 | 17·0 ± ·01 |

**B.** A Comparison of Body Proportions.

The relations of the body parts measured to the standard length of the two species was investigated. The data were expressed in the form of a double logarithmetic plot. Huxley (1922) has shown that the logarithms of any body measurement when plotted against the logarithms of the body length give a straight line relationship over a considerable size range which can be expressed by the equation $\log y = \log b + a \log x$.

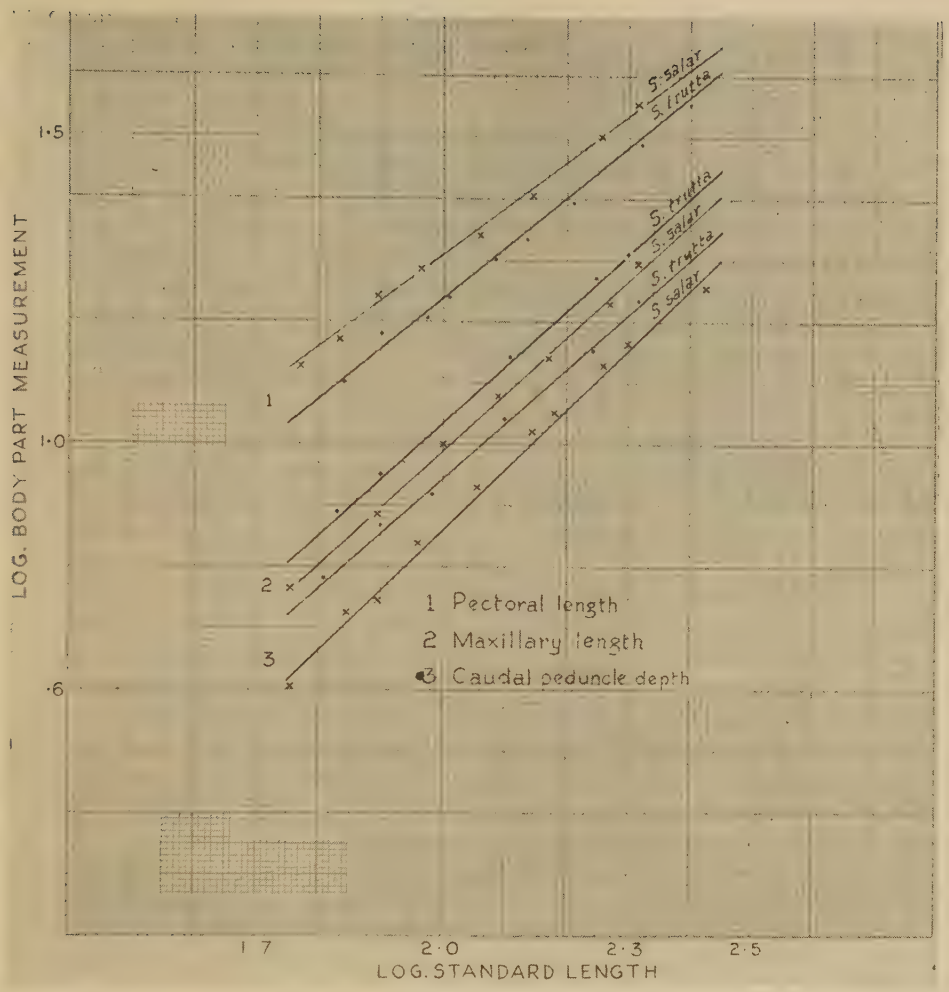


**FIGURE I.**
**Relation of Measurement of Body Part to Standard Length.**
**A Double Logarithmic Plot.**

All body measurements recorded were plotted in this way. Distinct lines for each species were found for the logarithms of (1) pectoral length, (2) maxillary length, and (3) caudal peduncle depth when plotted against logarithms of standard length for fish of lengths of 50 to 250 millimeters. These lines are shown in figure 1. Other measurements showed a less marked or no difference in the two species.

C. Application of Data to Distinguish *Salmo salar* from *Salmo trutta.*

The difficulty in distinguishing young Atlantic salmon from brown trout in streams which both frequent has been realized. For this reason a consideration of methods by which they may be distinguished is given.

The double logarithmetic curves on graph I show distinct curves for each species when pectoral length, maxillary length, and caudal peduncle depth are plotted against the standard length.

From Figure I it may be seen that (1) the pectoral fin of the young salmon is proportionately longer than that of the brown trout, (2) the maxillary length of the young brown trout is proportionately longer than that of the salmon, and (3) the caudal peduncle of the salmon is more slender than that the brown trout.

The twelve larger specimens with lengths of from 300 to 780 millimeters showed the caudal peduncle of the salmon to be more slender than that of the trout. Further, the meristic counts presented in Table I were found to be valid.

These data are presented in the following tabulated key as the ratio of the body part meaurement to the standard length. It is hoped that this key may provide a means of distinguishing the two species.

**Table II**

DISTINGUISHING CHARACTERISTICS OF ATLANTIC SALMON *(Salmo salar)* AND BROWN TROUT *(Salmo trutta)*

| CHARACTER | *Salmo salar* | *Salmo trutta* |
|---|---|---|
| Number of scales in oblique row from posterior base of adipose to lateral line... | FEWER THAN 13 | MORE THAN 13 |
| Number of gill-rakers on first arch on left side | MORE THAN 18 | FEWER THAN 18 |
| Number of branchiostegals on left side..... | GENERALLY 12 | GENERALLY 10 |
| *Ratio of maxillary length to standard length | LESS THAN 1/10 | GREATER THAN 1/10 |
| Ratio of caudal peduncle depth to standard length..... | LESS THAN 1/13 | GREATER THAN 1/13 |
| *Ratio of pectoral length to standard length | GREATER THAN 1/5 | LESS THAN 1/5 |

* Limited to lengths of from 50 to 250 millimeters.

# Small Mouthed Black Bass in the Waters of New Brunswick and Nova Scotia

*by*

**James Catt**

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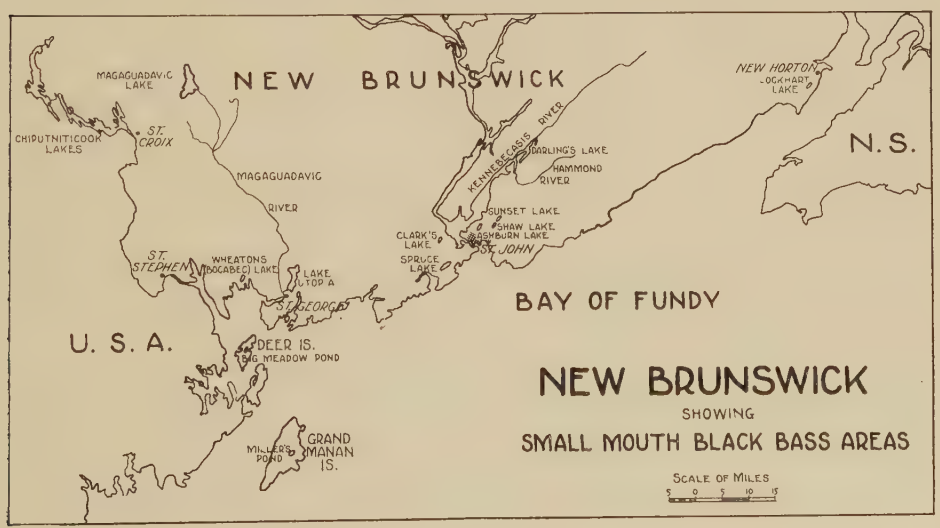
Although the small mouthed black bass *(Micropterus dolomieu)* is not native to the Maritime provinces, after introduction it has been established in some New Brunswick localities for many years. Recently its range has been extended by transfer to certain carefully selected waters in Nova Scotia.

The exact details of the method by which and the time at which the species entered New Brunswick are not available but from present information it seems that the first appearance was in the Chiputniticook lakes on the New Brunswick-State of Maine border *about 80 years ago.* It is believed that they obtained access to the lakes from a pond in Maine privately-owned and stocked by a bass angling enthusiast. This pond drains into the International water. *About 20 years later* bass appeared in the Kennebecasis river and Spruce lake both of which discharge into the tidal portion of the St. John river. Following this two small privately-owned lakes were stocked presumably with parent fish taken from the Kennebecasis, namely, Ashburn lake, St. John county, discharging into Courtenay bay, Saint John harbour, and Sunset lake draining into St. John river through a swamp and the lower Kennebecasis. It appears that the swamp acts as a barrier to migration, otherwise the bass would probably be found in Dolans lake.

*In 1905*, 13 bass were introduced into Lockhart lake, N.B. *In 1908*, 300 fingerlings were taken to Laytons lake, N.S. *In 1922*, 27 were placed in Wheatons lake, N.B. *In 1925*, Big Magaguadavic lake was stocked with 143 parent fish from Spendic (Chiputniticook) lake.

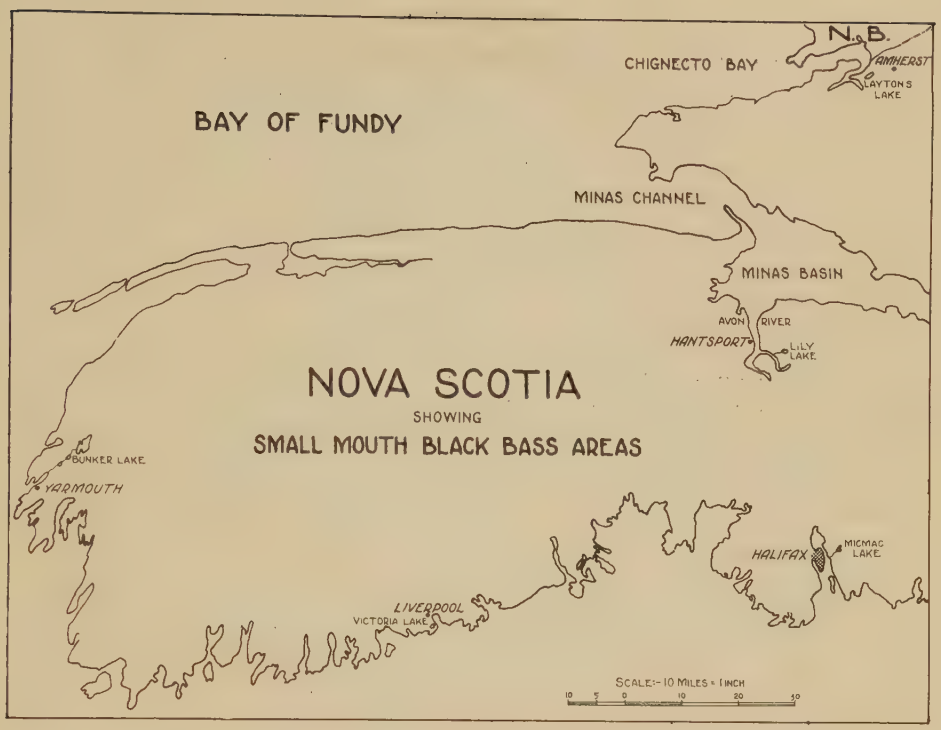


Following this last stocking the Federal Department of Fisheries seriously considered the effect of the introduction of non-indigenous species on the native forms such as the speckled trout *(Salvelinus fontinalis)* and Atlantic salmon *(Salmo salar)*. Although the black bass is an excellent game fish and could inhabit warmer water than the others, there was danger that it might through migration and predation supplant species which were more highly prized. As a result, a regulation was made prohibiting the introduction of any non-indigenous fish to any water without permission of the Minister. The result was that later extensions of range were limited and controlled at least to the extent of examination of areas before transplantation.

In September, *1925*, 42 adults from Spendic lake and Hammond river were transferred to Wheatons (Bocabec) lake, N.B. In *1942*, 107 adults were taken from Wheatons lake to Bunker lake, Nova Scotia, and 27 from the same body of water were placed in Big Meadow pond, Deer Island, N.B. In *1943*, 38 bass from Lake Utopia in the Magaguadavic watershed were taken to Miller's pond, Grand Manan, N.B. In *1944*, from a number of bass captured at the mouth of Trout brook, Lake Utopia, N.B., 61 were taken to Micmac lake, Halifax county, N.S., and 21 to Shaw lake, St. John county, N.B. In *1945*, 33 Lake Utopia bass were planted in Layton lake, Cumberland county, N.S., and in *1946*, 37 were also transferred thereto and 14 planted in Shaw lake, N.B. During *1947*, Victoria lake, Queens county, Nova Scotia, received 39 bass and Shaw lake, St. John county, N.B., 4. Of these, 17 were captured in Wheatons lake and the balance in the Magaguadavic watershed. In *1948*, 44 bass from Lake Utopia were taken to Lily Lake, Hants county, N.S., and 7 to Clark's lake, St. John county, N.B.

The unpreventable and unauthorized advent of the small mouthed black bass from United States waters into Chiputniticook lake was followed by a rapid diminution in the numbers of speckled trout, whitefish *(Coregonus clupeaformis)*, and to a lesser degree, sebago salmon *(S. salar sebago)*. As the bass spread down the St. Croix river, the trout fishery continued to decline both in the mainstream and some of the tributary brooks and lakes. The unauthorized introduction of the species into Magaguadavic lake was even more disastrous since the watershed included some of the finest speckled trout waters in the province where now the bass are found in increasing numbers.

The introduction into Kennebecasis, on the other hand, presents an unusual and interesting case where a trout fishery has apparently been little affected by predator exotics. In the locale of their distribution, including Darling's lake and the delta of the Hammond river at its confluence with the Kennebecasis, the waters have never really provided good trout habitats but have always contained large numbers of pickerel *(Esox niger)*. Perhaps peculiarly the bass do not appear to have spread upstream any considerable distances into the better trout areas. Their downstream expansion seems to have stopped where the river enters the very brackish tidal waters of the St. John although it is possible that some may have reached the Grand Bay area when heavy freshets offset the normal salinity. Undoubtedly the bass do take




some toll of smolts descending the Kennebecasis and Hammond but this is not believed to be serious. In Sunset lake although the body of water is small and the bass are reported to grow to a fair size (2 to 2½ lb.), the trout population has succeeded in maintaining itself to some degree.

In recent plantings bass have been limited to waters considered unfavourable to the indigenous species, *e.g.*, Wheatons lake, or to those from which it is evident they cannot migrate to other areas, *e.g.*, Ashburn, Sunset and Spruce Lakes.

Reports are not complete for all the various areas in which introductions were made in addition to the St. Croix, Magaguadavic, and Kennebecasis systems. It is known that the experiment with Lockhart lake in 1905 was a failure probably because a break in the dyke let the sea water into the lake. It is suggested that the 300 fingerlings taken to Laytons lake in *1908* were consumed by perch predators. The *1922* planting in Wheatons lake apparently did not succeed since by *1925* none were reported. The later attempt in *1925* was eminently successful. Miller's pond in Grand Manan, after a three-year closure, produced in *1946*—146, *1947*—85, and *1948*—67. The drop in the last two years is ascribed to less intensive fishing rather than to a decrease in population. Reports indicate that some bass were captured during 1948 in the Shaw lake watershed which includes Kelly and Quinn lakes. Anglers have also reported taking bass in the Micmac lakes.

## DISCUSSION

The history of the black bass in New Brunswick and Nova Scotia makes generalizations and prediction of results of future introductions difficult. In some instances success has been attained in providing angling to meet the rapidly increasing demands both from residents and tourists and there is no doubt that some waters not entirely suitable for trout and salmon are now productive. On the other hand, there is no doubt that in some areas the more valuable fisheries have been reduced without the establishment of an equally valuable one.

The bass has numerous commendable attributes. It is a game species which provides an excellent fight when taken on baits, plug, spinner or fly. It is palatable although to some perhaps not as desirable as the trout. It is a warm water species and can be fished to good advantage in the summer months when the main trout fishery is past. Being a warm water species, it should utilize to some extent the littoral waters in the summer when they are vacated by the trout.

Because the species may be very detrimental to indigenous forms, it is considered that further introduction should be carefully considered. One must be sure to limit it to areas where little or no harm can be done. In the meantime investigations should be carried out to determine more about its life history, growth, behaviour, habits and habitats. Certain valuable data could now be obtained by examining and recording information on conditions and yield, etc. , in the many new areas where plantings have been made. Only after a fairly complete and satisfactory picture of the species is obtained, would it be safe or wise to consider any relaxation in the present restricted planting policy.

# The Status of the Hatchery

*by*

**Richard B. Miller**

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(This paper was given at the Alberta Provincial Government—National Parks Fisheries Conference held in Banff, Alberta, in September, 1948.)

The subject of the efficiency or otherwise of sport fish hatcheries has been threshed over many times in the last few years. We ourselves discussed it briefly at our 1945 meeting in Jasper. But to us who are still, mainly, hatchery men, the subject should be, and I hope is, a very important one, worthy of our consideration.

I propose to give you first, a review of the research done in the United States and other parts of Canada on this topic; second, I wish to try to evaluate what the hatchery has done in Alberta; and third, I shall suggest what role the hatcheries should play in Alberta in the future.

## Review of Research in Hatcheries

The pioneer work of this sort was begun in the 1920's in Canada by Dr. R. E. Foerster of the Pacific Biological Station at Nanaimo, B.C., of the Fisheries Research Board of Canada. The Dominion had been spending large sums in the operation of the salmon hatcheries in British Columbia and it was decided to find out if these expenditures led to any results. The sockeye salmon come up the Fraser river and into small headwater lakes. Here they spawn on the beaches or in gravel beds of the tributary streams. The fry hatch in the spring and after a variable period in the lake (one to several summers) go to sea. Dr. Foerster's work was done on Cultus lake where from 5–80 thousand fish spawned each year. A hatchery was located here and screens across the lake outlet were built so that all fish entering or leaving were stopped and counted. The experiment tested three things. (1) The fish were counted and allowed to spawn naturally. The downstream migrants (their progeny) were counted the next year. (2) The fish were counted, their eggs taken and reared in the hatchery to be planted as eyed eggs—and the downstream migrants counted as before. (3) The fish were counted, then eggs taken, and reared to the fry stage—planted and down stream migrants taken. The experiment lasted ten years, the methods being used alternately. Over the years, the number of eggs which survived to the downstream migrant stage varied from 1–3 per cent for natural, 2–4·5 per cent for fry and 1–4·7 per cent for eyed eggs. There is no significant difference between these figures and salmon progation was discontinued in B.C.

Foerster's work brought out another interesting point; the mortality of 94–97 per cent occurring in all methods took place *after* the fry stage was reached. Natural fertilization and subsequent hatching were close to 100 per cent efficient. Nothing can be gained over nature by fertilizing and hatching in a hatchery.

Subsequent work has shown this to be generally true for trout. Investigations into the efficiency of natural fertilization have revealed that Cutthroat trout are over 90 per cent, Brown 99 per cent and Brook and Rainbow trout over 80 per cent efficient in nature.

Foerster's work (1936) touched off a great deal of similar research in the United States. Fry or fingerlings were marked by fin-clipping, liberated in streams, and the angler's catches carefully examined during the succeeding years. The first phase of this work was with fry and fingerlings.

Virginia, 1936—1·5–6 per cent return of 4 inch fingerling trout.
Virginia, 1940—268 trout recovered of 11,107 planted in one stream (2·4 per cent).
California, 1941—130,000 brown trout fry yielded 0·2 per cent.
10,000 speckled trout fry yielded 0·8 per cent.
Michigan, 1939—No returns of brook trout over 1·6 per cent.

These studies demonstrate the futility of planting fry or fingerlings in streams.

Studies on lakes give more encouraging results. Thus in California lakes Needham and Sumner (1941) found:

5,028 2-inch Eastern Brook Trout yielded 4·3 per cent to angler.
2,080 5-inch Eastern Brook Trout yielded 25·6 per cent to angler.

But in lakes where trout already existed, returns were not so good. In Fish lake, where rainbow are native, Needham and Cliff (1938) found that only 1·15 per cent of planted eastern brook were taken by anglers.

Using all three common trout, Wales (1946) tested fingerling survival in Castle lake, California. He found 3·5, 5·5 and 1·9 per cent of rainbow, brown and brook fingerling, respectively, survived.

In June lake, California, where no native fish spawn, Vestal (1943) observed 54 per cent survival to anglers of 100,000 planted trout.

It is readily apparent, then, that survival of fry and fingerlings is much better in lakes than in streams, but mainly in lakes where no native trout were present or spawning facilities not available.

As the survival of fry and fingerlings proved to be so poor, especially in streams, hatcheries began to plant larger and larger fish. Now the main plants are of "keeper" or legal size trout. The first research was to determine when it was best to plant these large fish. Some of the findings are as follows:

| Place | Authority | Kind of Trout | Survival for Spring plant % | Survival for Fall plant % |
|---|---|---|---|---|
| Michigan | Shetter and Hazzard 1942 | Brook<br>RB<br>Brown | 25·5<br>19·6<br>11·3 | 4·4<br>4·9<br>5·8 |
| Pine R., Michigan | Shetter and Hazzard 1938 | Brook<br>RB | 1·8<br>17·5 | —<br>— |
| Michigan<br>Michigan | Shetter and Hazzard 1941<br>Smith 1941 | All varieties<br>Brook | 4·9–61·9<br>19·6 | 5·3<br>1·0 |
| Connecticut | Hunter, Thorpe and Grosvenor 1941 | All species | 41·8–33·3 | — |
| Massachusetts | Nesbitt and Kitson 1937 | All species | 35·0 | 7·0 |
| N. Carolina | Chamberlain 1943 | RB | 44·0 | 2·3 to 5·5 |
| Minnesota | Smith, L. L. 1943 | Brook and Brown | 14·1 | 1·9 |
| Wisconsin | Williamson and Schneberger 1943 | Brook and RB | 25·0 | — |
| Pennsylvania | Trembley, G.L. 1945 | All species | 50·8 | |
| Castle Lake, Calif. | Wales, 1946 | All species | 35-40 in lake | |
| Arizona and New Mexico | Gee 1942 | All species | 45·1 | — |

This great body of evidence shows a return from spring planted legal-sized fish of about 5–50 per cent, average around 30 per cent. From fall planted fish the returns are, with a few exceptions, negligible. This suggests that the planted fish fail to survive over the winter. Investigation has shown that this is indeed the case. The reason that spring plants give returns is that they are caught the *same season* they are planted.

Shetter (1947) found that in Michigan streams, spring planted legal trout were caught in the first two weeks of open season. Those not caught then were never caught. Likewise, Williamson and Schneberger (1943) in Wisconsin found no survival to second season.

Trembley (1945) in Pennsylvania found 76 per cent of recoveries of planted trout were made in the first day of season. After six weeks, negligible numbers

of planted fish were caught. Smith and Smith (1945) found most were caught in the first three to four weeks of the season in Minnesota streams. They found only two per cent turning up the following season.

The causes of this failure to survive are not surely known. Needham and Slater (1944) have shown that competition with native fish for food will eliminate hatchery fish in streams they have studied. Schuck (1948) suggests that hatchery fish do not survive because (1) they have been poorly fed; (2) no exercise; (3) have had too constant temperature; (4) they are injured in handling.

It boils down to this fact; hatchery fish, even 7–8 inch fish, will not survive over winter in streams where there is a population of native fish of their own kind. The hatcheries in the U.S., therefore, are giving this kind of fishing:

Chamberlain (1943) reports that in the Pisgah Forest, North Carolina, anglers spend $1.00 per day to catch 8-inch Rainbow trout weighing 3½ ounces.

King, Willis (1942) report that in Great Smoky Mountain National Park three years of fishing yielded 133,638 trout of which:

114,050 were under legal size.
19,588 were legal—averaging 8·7 inches long.
285 were over 12 inches.
13 were over 16 inches.

**Hatchery in Alberta**

We have reviewed what has been discovered about hatcheries in the United States. Let us now look over the situation in Alberta.

The Rainbow Trout.—Over the past twenty years, an enormous effort has been made to establish this species in Alberta waters. From 1941–1945, 977,000 have been placed in Lake Minnewanka, with no showing. About five million have been planted in the Bow and its tributaries. The showing is not impressive. Only in lakes of this drainage has success been achieved, notably the Kananaskis lakes. Little success has followed plants in the Oldman drainage. Nowhere on the Saskatchewan drainage streams has a real population of rainbow been established. Apparently they are unable to compete with the native cutthroat trout. The plantings appear to have created a new fish—a rainbow cutthroat hybrid, but we do not know, as yet, if this fish can maintain itself.

In the Athabaska drainage, there is no native cutthroat and here the rainbow has taken a firm hold. In the McLeod and its tributaries, they are enormously abundant. But this water is poor in food and too cold for rainbows. As a result, it is rare, indeed, to catch one over two ounces in weight. These poor little dwarfs actually mature and spawn, grow old and die, without achieving legal length.

We must conclude that most Alberta streams are not suited to rainbow trout, but that some of our lakes are. It is possible that the migratory habits of rainbow explain, in part, why they have disappeared from streams and remained in lakes.

With brown trout we have had better success. This fish seems able to establish breeding populations in cutthroat streams possibly because it spawns at a different time of year. It has also proved suitable in warmer streams which previously contained no trout.

Similarly, brook trout, with different spawning season and habits than cutthroat, can establish themselves among them. Also, many of our waters are too cold to make good cutthroat streams and here brook trout should be tried. Recent trials on the Sheep and Highwood and Elbow look very promising.

## CONCLUSION

What is the hatchery man to conclude from all this? Is the hatchery no good and should it be abandoned? Or, if it is some use, what should our planting policies be?

I would say the hatchery is definitely necessary to a sport fishery, but it should be used differently than it has been in the past.

We should not regard the hatchery as a machine to turn out fish for anglers to catch. We cannot afford to raise legal fish and we have not the facilities to plant them in all streams before the fishing season opens. This provides poor fishing anyway—7-8 inch fish weighing two ounces—and we now have better fishing from native stocks. Instead, we should look upon the hatchery as first, an experimental instrument, and second, as an "ace-in-the-hole" in case of disaster.

With regard to the first use, as an experimental instrument: if a stream is providing fishing, it is useless to plant fish in it. But if there is reason to believe another species would give better fishing, then use the hatchery, *e.g.*, brook trout in the Macleod and upper Bow tributaries where the present trout make a poor showing in the cold water.

Or, where there are no native trout, the hatchery may be used to try and establish a population. Once a spawning population is established, the hatchery's task is done.

Or, in lakes and, perhaps, in some streams, where a hatchery-introduced population has no spawning grounds, annual plantings may be necessary and desirable.

The second use of the hatchery is as an "ace-in-the-hole". Our east slope streams are subject to natural disasters, particularly seasons when the water may be very low in the fall. As our native trout winter in the small streams, very severe, perhaps complete winter kills may result. The hatchery should always have on hand a supply of native trout to re-establish such streams.

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# Trout Fisheries in New Zealand—Their Development and Management

*Review by*

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*Trout Fisheries in New Zealand—Their Development and Management.* By Derisley F. Hobbs, New Zealand Marine Department, Fisheries Bulletin No. 9. Wellington, 1948. 175 pages, 31 plates, 4 text figures.

This paper written by an author who has established an enviable reputation for careful and wide scrutiny of literature, for meticulous attention to the detail of his data, for sound and conservative conclusions and for clear simple presentation, is certainly one of the most, if not the most, comprehensive recent publication on the problems of trout fishery development. While the material refers particularly to New Zealand, the principles enunciated have world-wide application and should be seriously considered by all those involved in the study of fish culture in the broad sense.

In this book the practices used for the maintenance of trout stocks in New Zealand are reviewed in the light of recent research both there and in other countries. Past operations are appraised and suggestions made for future policy. It is evident that much information is wanting to settle controversial problems but the presentation serves a useful purpose in drawing attention to the gaps in the essential knowledge.

Four main subjects are treated:

I—*Historical.*—Including a review of the administrative organization in the country, the general history of the fish introductions and the factors which have affected the development of the fisheries. The latter involves a discussion of environmental changes such as erosion, vegetation, water diversion, pollution, etc., the history of the trout stocks, their behaviour and changes in abundance, and the development and distribution of angling.

II—*Recent Management of the Fisheries in New Zealand.*—Herein the author presents an analysis of the expenditures and incomes from the fisheries, the theoretical basis of hatchery policy, the scope and nature of their operation, an analysis of losses in artificial propagation in all stages compared with those in nature and a discussion of the significance of the quantities produced in hatcheries.

III—*Recent Investigational Work on Fisheries Management in Other Countries.*—This section brings together most of the information from investigations comparing the results of artificial and natural propagation. Losses of artificially propagated trout after liberation are discussed. The relative values of the use of fry, fingerlings or older fish are presented as well as the stocking of lakes by hatcheries.

IV—*Future Management and Development of Fisheries.*—After reviewing past stocking and exploitation, the author discusses the development of new fisheries and the management of existing ones. Complete analysis is presented of the possible use of hatcheries, the chemical improvement of environment through control of pollution and fertilization, etc., the biological improvement of conditions by introduction of food organisms and control of predators and competitors, and the physical improvement of environment toward gaining better spawning grounds, increased cover, etc. Under Fisheries Protection, the subjects of poaching, fish salvage and the effect of regulations are treated at length, finally turning to the question of administration.

Supporting data for some of the conclusions are included in five short appendices at the end of Hobb's report.

The following conclusions are reached on the basis of the available evidence:

(1) There is no evidence which suggests that throughout New Zealand in the last sixty years there has been a progressive deterioration in the capacity of most waters to produce trout.

(2) The available evidence is against the view that any serious deterioration of stocks has occurred in the last fifty years. The average size of brown trout has been fairly well maintained. A tremendous increase in total angling effort has taken place since before 1900. There is no doubt that in many waters there has been a sustained higher yield than in early times but the sharing of this yield among more anglers may have caused a drop in the catch of the individual.

(3) The demand for angling appears to have increased more than proportionately to the increase in population.

(4) Geographic distribution of angling does not follow the spread of human population but is greatly conditioned by the quality of fishing.

(5) In most districts the major portion of the revenue has been used in hatchery work.

(6) In the initial *acclimatization phase* when new species were being introduced and spread, hatcheries were useful for reception of eggs and assembly of stocks for distribution.

(7) From small seedings, stocks have developed well or poorly in accordance with the suitability of environments for natural propagation, growth and survival. The present distribution and density of populations represent this suitability rather than the extent of releases of artificially propagated fish.

(8) For the *maintenance of stocks*, artificial propagation in New Zealand does not add significantly to the total quantity of trout since it is not usually an appreciably more efficient process than natural.

(9) Eggs have been collected from most easily obtainable wild stocks rather than from unexploited populations or from those where there is poor expectation of survival.

(10) Exploitation of stocks for eggs includes cases where not only the fish stripped but many others were denied access to the good spawning grounds thereby. In one case, however, the eggs removed were in excess of what could have been accommodated by the available beds.

(11) Artificial propagation even at great cost, can only be applied to a small fraction of the total eggs produced. For this reason, even if it were applied only in waters where there was an extremely high expectation of loss, it could not cause a significant increase in total stocks.

(12) The transfer of hatchery eggs which comprised only small fractions of those available in very few waters, has affected only a nominal reduction in the collection district and has made only nominal additions to populations in the locality of release.

(13) In certain lakes where survival conditions are good, small fisheries have been maintained by transfers of fish some of which were drawn from hatcheries.

(14) Preoccupation with artificial propagation of a fragmentary number of total eggs has led to neglect of reasonable protection of the natural spawners and their progeny and of other possibilities of management certainly not more speculative than artificial propagation.

(15) Bag limits appear to have had no general significant general effect in the conservation of stocks and size limits have had a possibly significant influence only in certain waters.

The author maintains that in addition to changes in the administrative machinery, three things are necessary if fisheries management is to be put on a sound basis.

> "The first of these is for a modest appreciation of the limited extent of present knowledge. The second is for a realization of the meagre extent of the resources and powers with which man seeks to maintain or modify stocks. Thirdly, there is need for the abandonment of measures based on assumptions and their replacement in part by measures warranted by existing knowledge, and, in part, experimentally, by those provisional measures indicated as most promising by such evidence as is available."

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